



U.S. Department of Energy  
Energy Efficiency and Renewable Energy

# Building Envelope

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WR Meadows



U.S. Department of Energy  
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Per the E.P.A

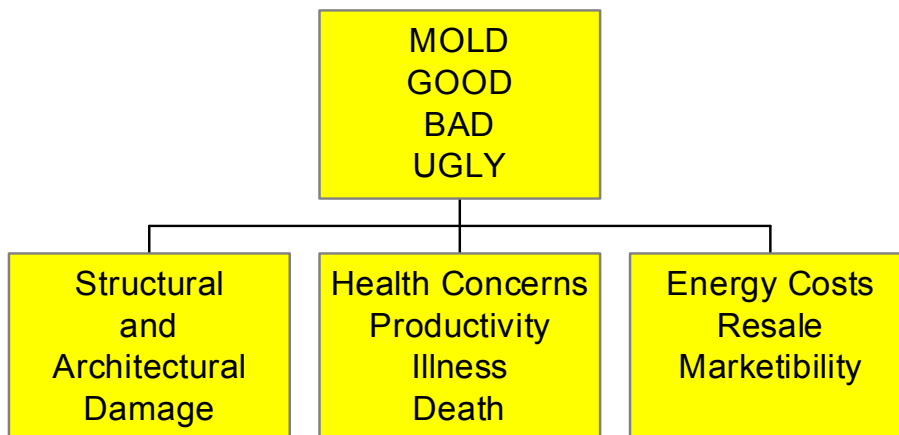
- 70-90% of our lives are spent indoors



The American Association of Home Inspectors found mold in 38% of the homes they inspected



## Moisture





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## Overview



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## What is an Air Barrier System?

An Air Barrier System is a system of building components within the building envelope designed and installed in such a manner as to stop the flow of air into and through the building envelope system.



## Why use Air Barrier Systems?

The U. S. Government now requires them on federal building projects.

The U.S. Department of Energy has determined that 40% of a buildings energy consumption to heat and / or cool the building is due to air leakage.

The use of Air Barrier systems result in:

- Reduced building energy consumption
- Reduced building heating and cooling costs
- Reduced fossil fuel consumption
- Reduced pollution emissions
- Reduction of the Greenhouse Effect
- Improved indoor air quality
- Reduced building envelope system problems

The U.S. Department of Energy has instituted a program of goals to reduce building energy consumption by 25% by the year 2010 and by 50% by the year 2020.

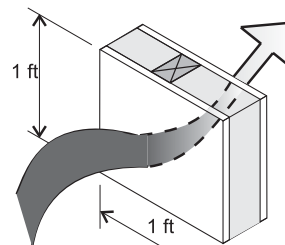
## Cross-cutting Issues Related to Building Envelope

Goals/Cross-Cutting Issues										
	Health and IAQ	Thermal Comfort	Visual Comfort	Acoustic Comfort	Security and Safety	Ecosystem Protection	Energy Efficiency	Water Efficiency	Materials Efficiency	Building as Learning Tool
Energy-Efficient Building Shell		●		●			●		●	●

## Building Envelope

# Heat Transfer through Building Envelope

- U-factor
- R-values
- Thermal Mass
- Heat Capacity



U-Factor is the rate of heat flow in Btu/h through one ft<sup>2</sup> area when one side is 1° F warmer

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## Heat Transfer through Building Envelope



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## Heat Transfer through Building Envelope

- **U-factor**
- R-values
- Thermal Mass
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## Flashing Details Are Very Important



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## Heat Transfer through Building Envelope

- U-factor
- **R-values**
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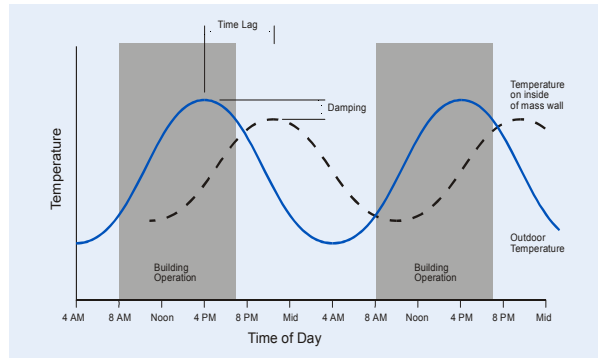
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## Heat Transfer through Building Envelope

- U-factor
- R-values
- **Thermal Mass**
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## Heat Transfer through Building Envelope



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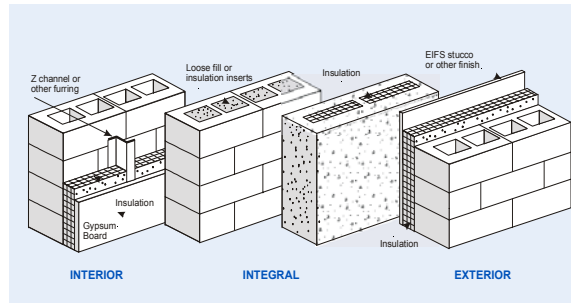
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## Heat Transfer through Building Envelope

- U-factor
- R-values
- Thermal Mass
- Heat Capacity



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## Minimum R-values from ASHRAE 90.1

	Climate Region						
	Hot and Dry	Hot and Humid	Temperate and Humid	Temperate Mixed	Cool and Humid	Cool and Dry	Cold and Humid
	(Phoenix)	(Orlando)	(Atlanta)	(Seattle)	(Boston)	(Denver)	(Minneapolis)
<b>Roofs</b>							
Insulation Entirely above Deck	R-15 ci	R-15 ci	R-15 ci	R-15 ci	R-15 ci	R-15 ci	R-15 ci
Attic and Other	R-30	R-30	R-30	R-30	R-30	R-30	R-38
<b>Walls, Above Grade</b>							
Mass	NR	NR	R-5.7 ci	R-5.7 ci	R-7.6 ci	R-7.6 ci	R-9.5 ci
Steel Framed	R-13	R-13	R-13	R-13	R-13+3.8 ci	R-13+3.8 ci	R-13+3.8 ci
Wood Framed and Other	R-13	R-13	R-13	R-13	R-13	R-13	R-13
<b>Wall, Below Grade</b>							
Below Grade Wall	NR	NR	NR	NR	NR	NR	NR
<b>Floors</b>							
Mass	R-4.2 ci	R-4.2 ci	R-6.3 ci	R-6.3 ci	R-8.3 ci	R-8.3 ci	R-8.3 ci
Steel Joist	R-19	R-19	R-19	R-19	R-19	R-19	R-30
Wood Framed and Other	R-19	R-19	R-19	R-19	R-30	R-30	R-30
<b>Slab-On-Grade Floors</b>							
Unheated	NR	NR	NR	NR	NR	NR	NR
Heated	R-7.5@12 in.	R-7.5@12 in.	R-7.5@12 in.	R-7.5@24 in.	R-10@36 in.	R-10@36 in.	R-10@36 in.

Note: "ci" means continuous insulation. "NR" means no requirement.

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## Recommended R-values for schools

	Climate Region						
	Hot and Dry	Hot and Humid	Temperate and Humid	Temperate Mixed	Cool and Humid	Cool and Dry	Cold and Humid
	(Phoenix)	(Orlando)	(Atlanta)	(Seattle)	(Boston)	(Denver)	(Minneapolis)
<b>Roofs</b>							
Insulation Entirely above Deck	R-20 ci	R-20 ci	R-20 ci	R-20 ci	R-20 ci	R-20 ci	R-20 ci
Attic and Other	R-38	R-38	R-38	R-38	R-38	R-38	R-60
<b>Walls, Above Grade</b>							
Mass	R-7.6 ci	R-7.6 ci	R-9.5 ci	R-11.4 ci	R-13.3 ci	R-13.3 ci	R-15.2 ci
Steel Framed	R-13+3.8 ci	R-13+3.8 ci	R-13+7.5 ci	R-13+7.5 ci	R-13+7.5 ci	R-13+7.5 ci	R-13+7.5 ci
Wood Framed and Other	R-13	R-13	R-13	R-13	R-13+7.5 ci	R-13+7.5 ci	R-13+7.5 ci
<b>Wall, Below Grade</b>							
Below Grade Wall	NR	NR	NR	R-7.5 ci	R-7.5 ci	R-7.5 ci	R-7.5 ci
<b>Floors</b>							
Mass	R-8.3 ci	R-8.3 ci	R-8.3 ci	R-10.4 ci	R-12.5 ci	R-12.5 ci	R-14.6 ci
Steel Joist	R-30	R-30	R-30	R-30	R-30	R-30	R-38
Wood Framed and Other	R-30	R-30	R-30	R-30	R-30	R-30	R-30
<b>Slab-On-Grade Floors</b>							
Unheated	NR	NR	NR	NR	R-10@24 in.	R-10@24 in.	R-15@24 in.
Heated	R-7.5@12 in.	R-7.5@12 in.	R-10@36 in.	R-10@36 in.	R-10	R-10	R-15

Note: "ci" means continuous insulation. "NR" means no requirement.

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## Measuring Thermal Performance

- Calculation Methods
  - Series
  - Parallel Path
  - Effective R-value
  - Two-dimensional
  - Testing
- Computer Programs
- Pre-calculated Data



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## Moisture Control

- Vapor migration occurs from the warm humid side to the cool dry side of the construction where it can condense and lead to mold growth.
- Install vapor barriers on the warm, moist side of framed walls, doors and roofs:
  - Outside of the assembly in humid climates.
  - Inside the assembly for non-humid climates.
- Provide adequate ventilation in attics, crawl space, wall cavities (only in extreme climates).

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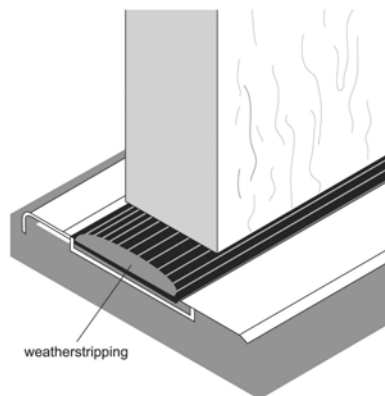
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## Air Infiltration

Strategies for reducing infiltration:

- Continuous air barrier on roof and walls.
- Windows/doors with low rates of infiltration.
- Weatherstripping.
- Using air lock entries in cold climates.



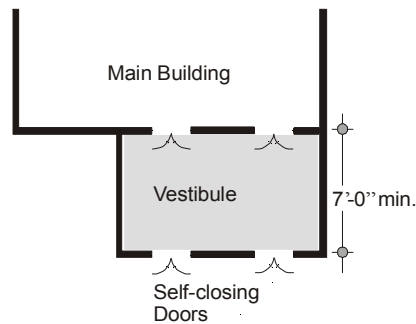
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## Air Infiltration

- Vestibule doors should be at least 7 feet from the school's main entrance.
- Vestibule doors should have self-closing devices.



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## Insulation Recommendations – Wood Framed Walls

- Install a minimum of R-13 cavity insulation in all climates.
- In the Cool and Humid, Cold and Humid, and Cool and Dry climates, also install R-7.5 insulating sheathing.

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## Insulation Recommendations – Metal-Framed Walls

- Install a minimum of R-13 cavity insulation in all climates.
- In the Hot and Humid and Hot and Dry climates, also install R-3.8 continuous insulating sheathing. In the other climates, use R-7.5 continuous insulating sheathing.

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## Insulation Recommendations – Mass Walls

- Install R-7.6 continuous insulation in the Hot and Dry and Hot and Humid climates.
- Upgrade this to R-9.5 in the Temperate and Humid climate, to R-13.3 in the Cool and Humid and Cool and Dry climates, and to R-15.2 in the Cold and Humid climate.
- Higher levels of insulation may be appropriate depending on local climate.

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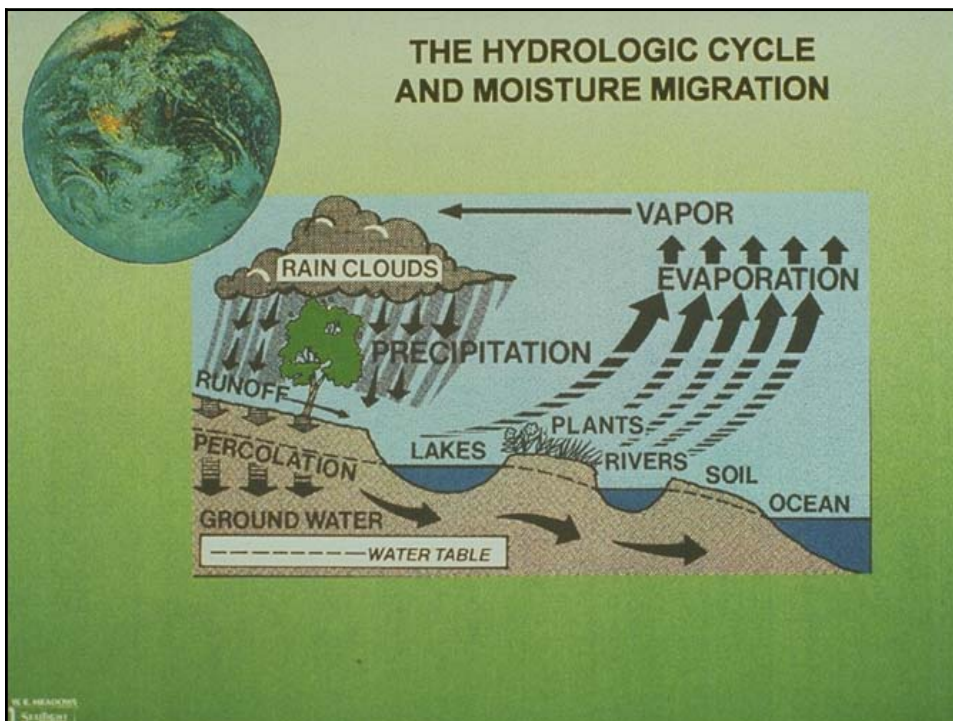


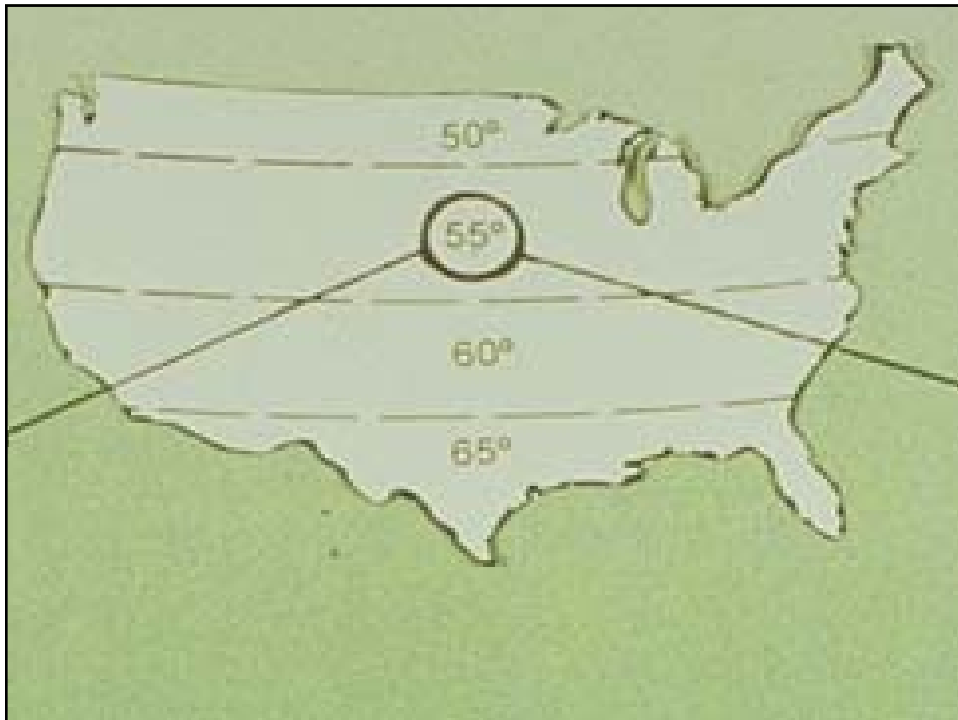
## Insulation Recommendations – Mass Walls



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# LAWS OF PHYSICS

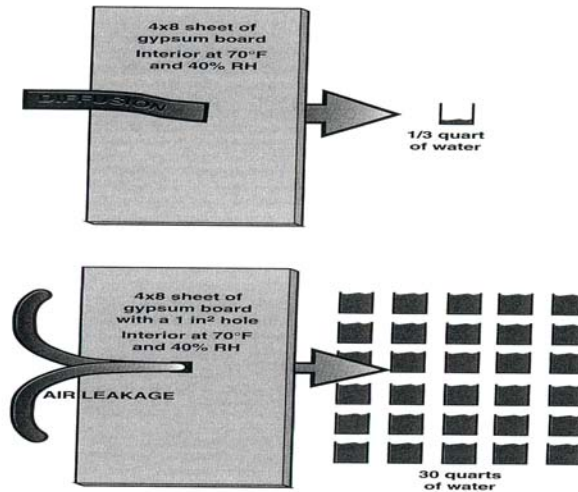
## VAPOR PRESSURE,

as a Function of Temperature & Relative Humidity

		RELATIVE HUMIDITY									
		100	90	80	70	60	50	40	30	20	10
TEMPERATURE	100	.948	.854	.758	.663	.569	.474	.379	.284	.189	.095
	90	.639	.621	.551	.482	.414	.344	.275	.209	.138	.069
	80	.506	.455	.405	.357	.303	.253	.202	.152	.101	.051
	75	.429	.386	.343	.300	.258	.214	.172	.129	.086	.043
	70	.362	.326	.290	.253	.217	.181	.145	.108	.072	.036
	65	.305	.274	.244	.213	.183	.152	.122	.091	.061	.030
	60	.256	.230	.205	.179	.153	.128	.102	.077	.051	.026
	55	.214	.192	.171	.149	.128	.107	.085	.064	.042	.021
	50	.178	.160	.142	.124	.107	.089	.071	.053	.036	.018

The above table is recommended for General Engineering

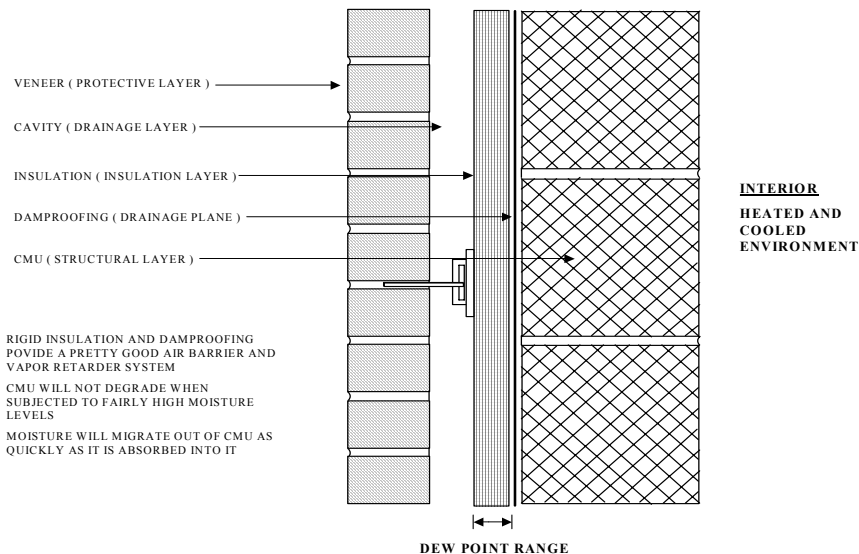




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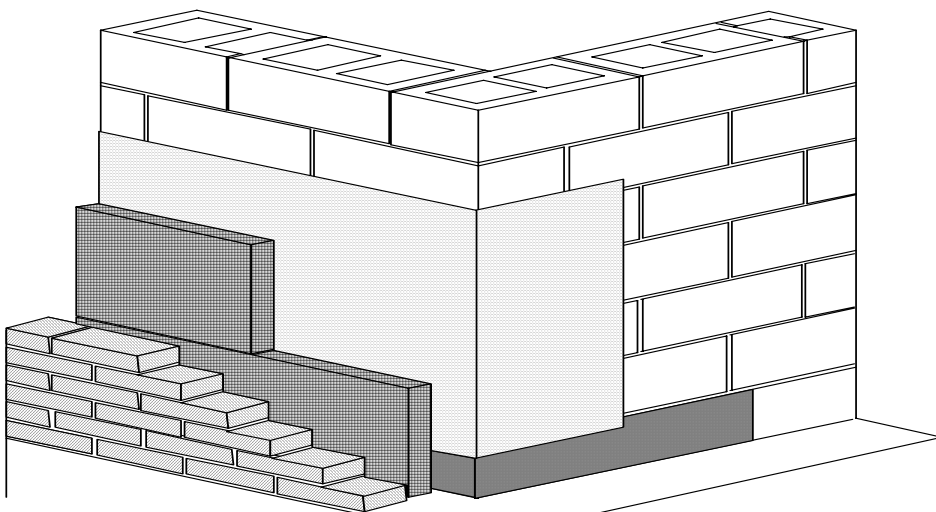
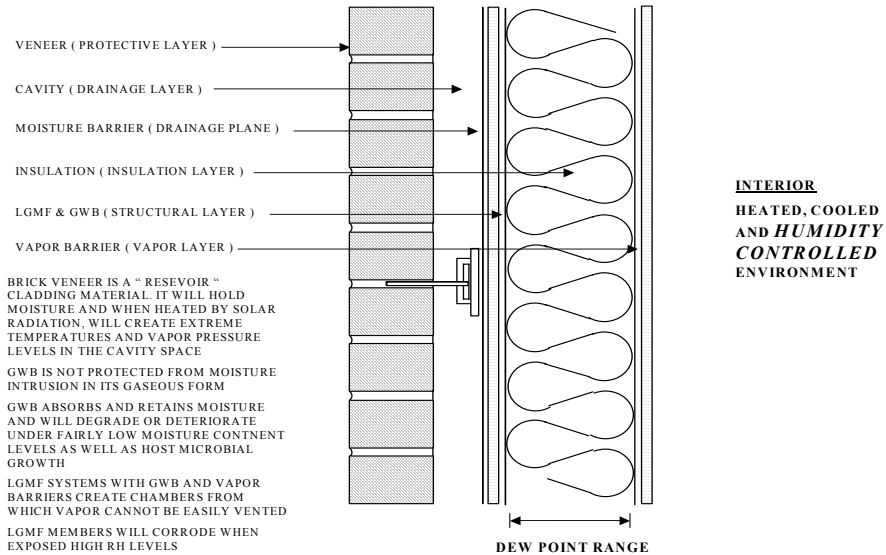


## BUILDING EXTERIOR WALLS 30 YEARS AGO



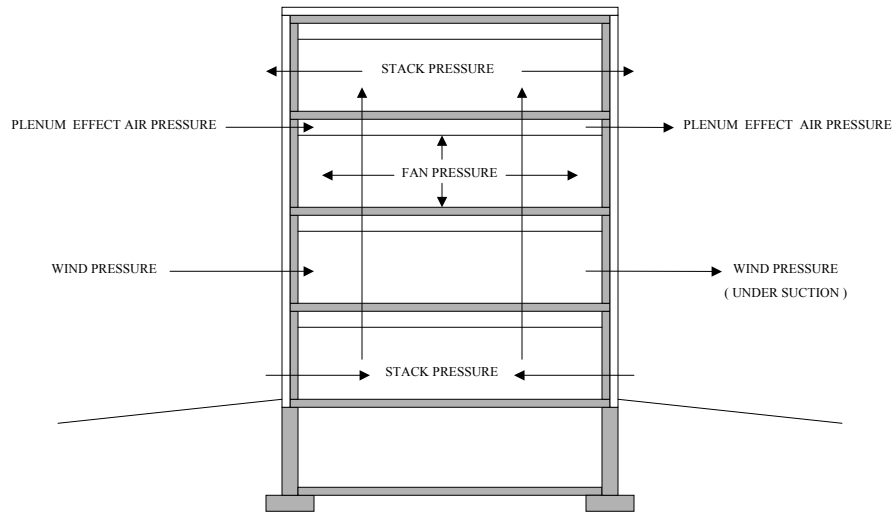


## Building Envelope Systems Today





# Pressures



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Epoxy Injection Ports should be spaced appropriately.



Example of what can happen when air flow relocates a building envelope system's dew point into the veneer layer.



### Air And Vapor Barriers

Metal  
Glass  
Modified bituminous self adhering membrane  
Modified bituminous torch grade membrane  
Foil back urethane insulation: 1" or thicker  
Foil back gypsum board: 1/2" or thicker  
Certain asphalt impregnated fiber board  
Certain fluid applied membranes  
Sealants ( Caulking )  
Plastic  
Certain trowel applied modified asphalt emulsions  
Certain urethane insulation materials  
Certain foam insulation

### Air Barriers

Plywood sheathing: 3/8" or thicker  
Smooth surface roofing membrane  
Cement board: 1/2" or thicker  
  
Extruded Polystyrene: 1 1/2" or thicker  
Gypsum board ( Use moisture resistant board )  
Concrete  
Phenolic insulation board: 15/16" or thicker



## Materials that do not meet the requirements to be an Air Barrier

Plywood sheathing: Less than 3/8" thick

Reinforced non perforated polyolefin

Tempered hardboard

Asphalt saturated felt paper: 15# and 30#

Plain fiberboard

Spunbonded olefin film

Vermiculite insulation

Concrete masonry units

Flakewood board

Particle board

Expanded polystyrene

Glass fiber rigid insulation board

Asphalt impregnated fiberboard

Glasswool insulation

Cellulose insulation

Brick



## Wall order of assembly

- Air barriers must be installed on the warm side of the insulation. This way, any moisture that forms will occur on the outside of the air barrier. The moisture will be reabsorbed into the exterior atmosphere or drained away through flashings and /or floor slabs.
- Thermal insulation must be in direct contact with air barrier membrane, installed tight. Direct contact between insulation and the air barrier prevents the generations of convective air currents that can lead to water vapor and condensation problems.

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## Wall order of assembly

- In hot and humid, air flow retarders should be installed on the exterior of the building, and building assemblies should protect the outside wall surface from getting wet. Any moisture should be allowed to drain away or dry toward the interior, using permeable interior wall finishes and avoiding wall coverings.

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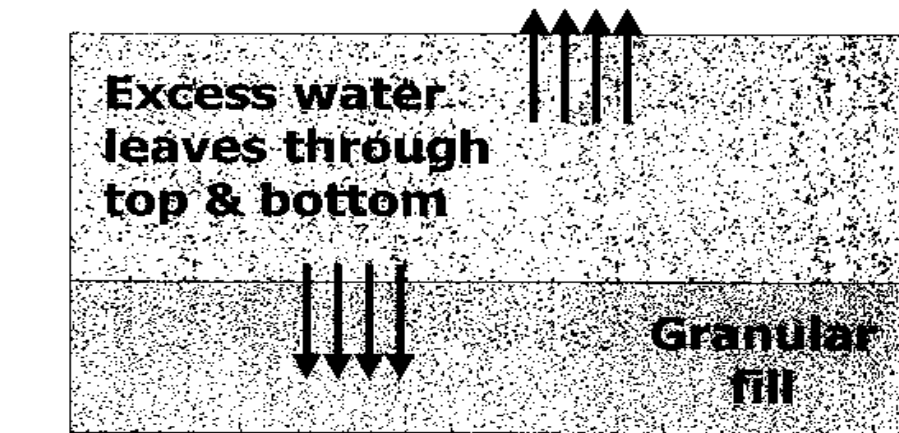


## Problems Related To Slab Moisture

- DUSTING** - water trowled into surface
- SCALING** - high permeability in surface
- BLISTERING** - premature finishing discolor
- CURLING** - differential drying/curing
- CRACKING** - excess water & evaporation

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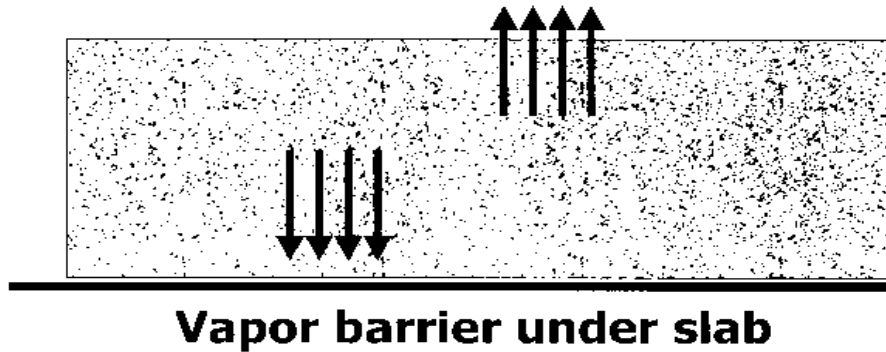
## Subgrade preparation





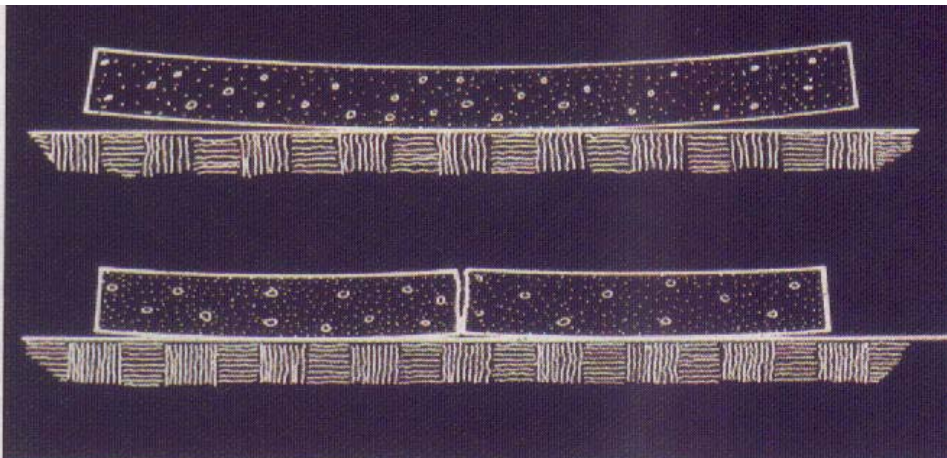
# Subgrade preparation

**Excess water can't leave  
through bottom of slab**



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Water cure can lead to:  
**Slab Curl**





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## Consider Durability

- **ASTM E 1993**

“Standard Specification for Bituminous Water Vapor Retarders used in Contact with Soil or Granular Fill under Concrete Slabs.”



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INSTALLATION TIMING IS CRITICAL



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PROTECT YOUR WATERPROOFING

